DeVRY INSTITUTE OF TECHNOLOGY

SOLID-STATE OSCILLOSCOPE

TROUBLESHOOTING MANUAL

ONE OF THE
BELL & HOWELL SCHOOLS

TABLE OF CONTENTS

SECTION I

INTRODUCTION TO THE BELL & HOWELL SOLID STATE OSCILLOSCOPE 3
- General Description 3
- How to Use This Manual 4
- Action of Controls 4
- Common Problems 6

SECTION II

CIRCUIT DESCRIPTION AND TROUBLESHOOTING 10
- Importance of Understanding Circuit Operation 10
- Block Diagram of Oscilloscope Circuits 11

VERTICAL CIRCUITRY 12
- Vertical Input Attenuator 12
- Vertical Input Amplifier 12
- Vertical Input Attenuator and Amplifier Test 13
- Vertical Output Amplifier 14
- Vertical Output Amplifier Test 15

TRIGGER SWEEP CIRCUITRY 16
- Trigger Signal Amplifier 16
- Trigger Differential Amplifier Test 18
- Trigger Sweep Circuit 19
- Sweep Trigger Circuit Test 22

HORIZONTAL CIRCUITRY 24
- Horizontal Input Amplifier 24
- Horizontal Output Amplifier 24
- Horizontal Input Amplifier Test 25
- Horizontal Differential Amplifier Test 26

POWER SUPPLY CIRCUITRY 27
- Low Voltage Supply 27
- High Voltage Supply 29
- Troubleshooting the Power Supply Circuit Board 30

APPENDIX

A -- Revised Vertical Calibration Procedure 32
B -- Transistor Test Circuit 34
C -- Zener Diode Test Circuit 36
D -- High Voltage Test 37
E -- Circuit Modifications 38
F -- Bell & Howell Oscilloscope Operational Report 39
G -- Schematic Diagram ..... Insert Page

SECTION I

INTRODUCTION TO THE BELL & HOWELL SOLID STATE OSCILLOSCOPE

GENERAL DESCRIPTION

An oscilloscope is a graphical display device that utilizes a sweeping electron beam to produce a visible trace on the screen of a cathode ray tube. The test signal, applied to the vertical input, is presented on the CRT screen as a line or lines on a graph. That is, the changes in amplitude of the test signal are "plotted" with respect to time. In effect, the scope uses a beam of electrons to draw a waveform on the screen just as you use a pencil to draw a waveform on a piece of paper.

The oscilloscope is divided into six sections: The Cathode Ray Tube, the High Voltage Power Supply, the Low Voltage Power Supply, the Vertical Amplifier, the Horizontal Amplifier, and the Horizontal Trigger Sweep section. All of these sections have one end purpose -- to display a pattern (trace) on the face of the cathode ray tube.

The cathode ray tube develops a beam of electrons that is shaped and accelerated by high voltages which are developed within the instrument. The electron beam is transformed into visible light energy when it strikes a thin layer of phosphor material on the inside of the CRT faceplate. The vertical and horizontal movement of the electron beam is controlled by the signals which are to be observed and by circuits in the oscilloscope.

To produce a picture of an applied voltage, the electron beam must be deflected or caused to move across the screen. The electron beam is deflected by electrostatic fields between two sets of deflection plates. A voltage applied between each set of plates causes electrons passing between the plates, on their way to the screen, to be attracted by the positive plates and repelled by the negative plates, thereby deflecting the electron beam both vertically and horizontally.

The horizontal and vertical deflection amplifiers increase the sensitivity of the oscilloscope by increasing or amplifying the input signals. The output signal is applied to the deflection plates of the CRT. If the input signals are too large, the deflection amplifiers will be overdriven. This causes distortion in the output signal waveform, and the pattern on the screen will not be a true picture of the input signal. This distortion is prevented by limiting the signal amplitude by means of an attenuator.

The oscilloscope also contains an internal circuit for developing the repetitive signal waveform that is applied to the horizontal deflection plates. This signal voltage, used to sweep the electron beam horizontally across the CRT screen, is produced by the Horizontal Trigger Sweep Circuit. The beginning of each sweep voltage waveform is applied to the horizontal amplifier section at the same time that the beginning of a cycle of the test signal is applied to the vertical amplifier section. The resulting display on the face of the CRT is thus stable and accurately represents the test signal.

The following sections of this manual will explain in greater detail how the oscilloscope circuits operate as well as the procedures necessary for troubleshooting.

HOW TO USE THIS MANUAL

This manual is designed to provide all necessary information required to effectively troubleshoot problems you may encounter with the Bell & Howell Solid State Oscilloscope. The most common troubles result from improper setting of the oscilloscope controls. Therefore, it is recommended that you read the section titled, "ACTION OF CONTROLS" first. After familiarizing yourself with the controls, perform the initial calibration procedures again to see if satisfactory results are obtained. If you still have negative results, turn to the "COMMON PROBLEMS" section and follow the instructions given under "SERVICING HINTS."

If you still experience difficulty, refer to SECTION II. Section II of this manual explains the circuit action of the complete oscilloscope and gives appropriate tests for troubleshooting the circuits. Discussed in detail are the Vertical, Horizontal, Triggering, and Power Supply circuits. The APPENDIX contains additional instructions for troubleshooting.

ACTION OF CONTROLS

Most problems related to the Bell & Howell Solid State Oscilloscope are due to improper control adjustment, descriptively referred to as "pilot error". Proper control adjustment and the symptoms of misadjustment are described as follows.

BEAM POSITION-VERTICAL and HORIZONTAL -- These controls adjust the vertical and horizontal position of the trace on the CRT screen.

> Inability to obtain a trace on the CRT screen may be the result of either of these controls being rotated excessively counterclockwise or clockwise. This causes the trace to be deflected beyond the normal viewing area of the screen. Centering these two control knobs should return the trace to within viewing area.

VERTICAL-VOLTS/CM and VARIABLE -- These controls permit adjustment of the vertical size of the trace.

> If these controls are misadjusted, the trace may be expanded far above and below the screen. The trace now may be so thin and poorly illuminated that it will not be visible on the screen. This excessive amount of input signal may also result in damage to the input circuit of the vertical amplifier.

MODE -- This switching circuit blocks DC signals when in the AC position. When in the DC position, the AC signal is displayed with it's DC component. If the DC component is excessive, the trace may be forced entirely off of the screen.

It is important to keep in mind that after a measurement is made in a high voltage circuit, when in the AC position, you should short the input leads in order to discharge the DC voltage that has been stored across the input capacitor. This is necessary because damage might occur to the circuit under test due to the discharge of the high voltage stored across the capacitor when the next measurement is made.

INPUT OPERATE/CALIBRATE -- This switch selects for display, either an input signal or an internal 1V P-P calibration voltage.

STABILITY CONTROL -- This control adjusts the sweep generator circuits for stable operation.

In the AUTO position of the AUTO/NORM switch, proper adjustment of the STABILITY control is made when it is rotated clockwise until the trace first turns on. When in NORM position, the LEVEL control must first be at maximum counterclockwise position before adjusting the STABILITY control. The STABILITY control is rotated clockwise until the trace first comes on and then rotated counterclockwise until the trace just goes off. Now, the LEVEL control is adjusted until the trace is stable. If the STABILITY control is advanced too far clockwise, instability will result. Instability may appear as a double trace, a half trace, a trace appearing to move off the right side of the screen, or a plain unstable trace. If a stable trace cannot be obtained, check the position of the INTENSITY control as it may have to be rotated fully clockwise in order to find the correct setting of the STABILITY control. Reduction of intensity can be made after stability is obtained.

HORIZONTAL WIDTH -- This control adjusts the width of the trace from a dot to a line expanding from left to right as the WIDTH control is rotated clockwise.

If WIDTH control is adjusted from maximum to minimum (counterclockwise rotation), the trace may seem to disappear off the left side of the screen. This is not a problem and is simply due to the fact that the horizontal amplifier is receiving a DC sweep signal.

uSEC/CM SWITCH -- This switch selects the time per centimeter for the beam to sweep the screen from left to right.

Misadjustment of this control or positioning the switch in the EXT position could result in no trace appearing on the screen or a trace that is impossible to stabilize. Also keep in mind that the EXT position means that an external signal must be applied to the horizontal input connector (HOR) to obtain a horizontal trace.

HORIZONTAL VARIABLE -- Allows adjustment of the sweep frequency.

This control is used for fine frequency selection for more detailed waveform analysis. This adjustment is necessary because in the calibrated positions of the uSEC/CM

switch, the sweep may be too fast resulting in too many waveforms or too slow resulting in only partial display of a complete waveform.

SWEEP TRIGGER-INT/EXT -- This switch allows internal or external signals to be used to trigger the sweep action.

With the switch in the EXT position, an external triggering signal must be applied to the EXT TRIG input, otherwise, you cannot achieve a stable synchronized trace.

LEVEL -- This control sets the amplification level of the trigger circuit amplifier. This allows you to initiate the sweep from any point on the input signal waveform from almost the negative peak up to the positive peak.

This control functions only when the SWEEP TRIGGER AUTO/NORM switch is in the NORM position. Proper range of adjustment can only be made if the internal TRIGGER BAL control on the sweep circuit board is properly adjusted. It is important to note that the LEVEL control must be used in conjunction with the STABILITY control. It is also important to remember that when this control is rotated beyond the range of stable adjustment, the trace will turn off.

SLOPE -- This switch selects the slope, positive or negative going, on which triggering will occur as adjusted by the position of the LEVEL control.

At this time, refer to the "COMMON PROBLEMS" Section.

COMMON PROBLEMS

Proper operation of the Bell & Howell Solid State Oscilloscope depends upon the correct setting of the front panel controls. Misadjustment of any one of these controls may prevent the trace from appearing on the CRT.

In order to correctly evaluate the cause of the trouble, the following procedures must be performed:

NOTE: With Oscilloscope turned OFF, remove optical coupler IC201 and set the front panel controls as shown below.

CRT DISPLAY

INTENSITY: Fully clockwise and pulled out to turn scope ON
FOCUS: Center of Rotation
VERTICAL POSITION: Center of rotation
HORIZONTAL POSITION: Center of rotation

TYPOGRAPHICAL CHANGE NOTICE

Please make the following corrections in your Solid State Oscilloscope Trouble-shooting Manual (5:SSOTM-2).

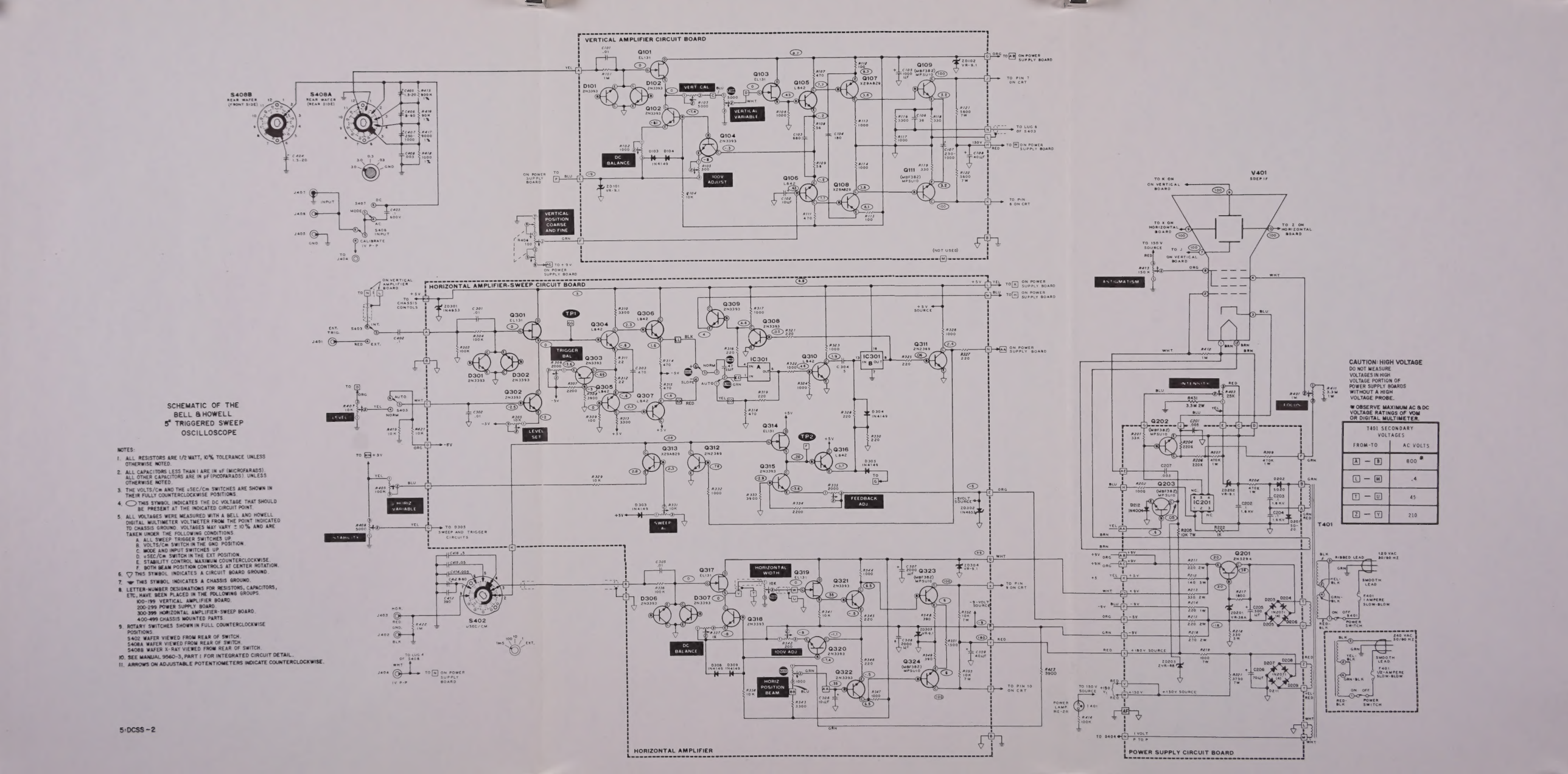
On page 19, Step 3, delete sentence #3 (Adjust the Trigger Balance for a 1 volt reading) as the acceptable range of adjustment is from 1 to 2.5 volts.

On page 23, the chart heading under Step 3 should be changed from "Level Control Settings" to "STABILITY CONTROL SETTINGS."

On page 35, in the test set-up for testing a PNP transistor, the Red test lead of the DMM is connected to Point "D".

Instruction Department

5:TESSOTM-2


SCHEMATIC OF THE
BELL & HOWELL
5" TRIGGERED SWEEP
OSCILLOSCOPE
NOTES:
1. ALL RESISTORS ARE 1/2 WATT, 10% TOLERANCE UNLESS OTHERWISE NOTED.
2. ALL CAPACITORS LESS THAN 1 ARE IN uF (MICROFARADS). ALL OTHER CAPACITORS ARE IN pF (PICOFARADS). UNLESS OTHERWISE NOTED.
3. THE VOLTS/Cm AND THE uSEC/Cm SWITCHES ARE SHOWN IN THEIR FULLY COUNTERCLOCKWISE POSITIONS.
4. THIS SYMBOL INDICATES THE DC VOLTAGE THAT SHOULD BE PRESENT AT THE INDICATED CIRCUIT POINT.
5. ALL VOLTAGES WERE MEASURED WITH A BELL AND HOWELL DIGITAL MULTIMETER VOLTMETER FROM THE POINT INDICATED TO CHASSIS GROUND. VOLTAGES MAY VARY ± 10% AND ARE TAKEN UNDER THE FOLLOWING CONDITIONS.
A. ALL SWEEP TRIGGER SWITCHES UP.
B. VOLTS/Cm SWITCH IN THE GND POSITION.
C. MODE AND INPUT SWITCHES UP.
D. uSEC/Cm SWITCH IN THE EXT POSITION.
E. STABILITY CONTROL MAXIMUM COUNTERCLOCKWISE.
F. BOTH BEAM POSITION CONTROLS AT CENTER ROTATION.
6. THIS SYMBOL INDICATES A CIRCUIT BOARD GROUND.
7. THIS SYMBOL INDICATES A CHASSIS GROUND.
8. LETTER-NUMBER DESIGNATIONS FOR RESISTORS, CAPACITORS, ETC., HAVE BEEN PLACED IN THE FOLLOWING GROUPS.
100-199 VERTICAL AMPLIFIER BOARD.
200-299 POWER SUPPLY BOARD.
300-399 HORIZONTAL AMPLIFIER-SWEEP BOARD.
400-499 CHASSIS MOUNTED PARTS.
9. ROTARY SWITCHES SHOWN IN FULL COUNTERCLOCKWISE POSITIONS.
S402 WAFER VIEWED FROM REAR OF SWITCH.
S408A WAFER VIEWED FROM REAR OF SWITCH.
S408B WAFER X-RAY VIEWED FROM REAR OF SWITCH.
10. SEE MANUAL 9560-3, PART 1 FOR INTEGRATED CIRCUIT DETAIL.
11. ARROWS ON ADJUSTABLE POTENTIOMETERS INDICATE COUNTERCLOCKWISE.
5-DCSS-2
VERTICAL AMPLIFIER CIRCUIT BOARD
HORIZONTAL AMPLIFIER-SWEEP CIRCUIT BOARD
HORIZONTAL AMPLIFIER
POWER SUPPLY CIRCUIT BOARD
S408B REAR WAFER (FRONT SIDE)
S408A REAR WAFER (REAR SIDE)
S407 MODE
S406 INPUT
CALIBRATE 1V P-P
INPUT
DC
AC
GND
VERT CAL
VERTICAL VARIABLE
DC BALANCE
100V ADJUST
VERTICAL POSITION COARSE AND FINE
TRIGGER BAL
LEVEL
LEVEL SET
STABILITY
HORIZ VARIABLE
SWEEP CAL
FEEDBACK ADJ
HORIZONTAL WIDTH
100V ADJ
HORIZ POSITION BEAM
S402 uSEC/CM
ASTIGMATISM
INTENSITY
FOCUS
V401
5DEP1P
T401
CAUTION: HIGH VOLTAGE
DO NOT MEASURE VOLTAGES IN HIGH VOLTAGE PORTION OF POWER SUPPLY BOARDS WITHOUT A HIGH VOLTAGE PROBE.
* OBSERVE MAXIMUM AC & DC VOLTAGE RATINGS OF VOM OR DIGITAL MULTIMETER.
T401 SECONDARY VOLTAGES
FROM-TO
AC VOLTS
A — B
800 *
L — M
.4
T — U
45
Z — Y
210
120 VAC 50/60 HZ
240 VAC 50/60 HZ
F401 1 AMPERE SLOW-BLOW
F401 1/2-AMPERE SLOW-BLOW
POWER SWITCH
POWER LAMP NE-2H

Digitized by the Internet Archive
in 2024 with funding from
Amateur Radio Digital Communications, Grant 151

https://archive.org/details/solidstateoscill00unse

VERTICAL

VOLTS/CM: 0.3
VARIABLE: Fully clockwise
MODE: AC
INPUT: Calibrate

HORIZONTAL

WIDTH: Fully clockwise
VARIABLE: Fully clockwise
uSEC/CM: "1mS"

SWEEP TRIGGER

LEVEL: Fully counterclockwise
AUTO/NORM: Auto
SLOPE: +(plus)
INT/EXT: Internal
STABILITY: Fully counterclockwise

After completing the above set-up, rotate the STABILITY control slowly clockwise until a stable trace appears. A display should appear somewhere on the oscilloscope screen. (If no trace is visible, continue reading the "SERVICING HINTS" section that follows.) Adjust the beam position controls to center the display and adjust the Focus and Intensity controls for sharpest image. If you have difficulty, repeat the Vertical and Horizontal calibrations in the 9560-3 manual, Part 1, "INITIAL ADJUSTMENTS" section. A modified version of the vertical calibration procedure is in the Appendix. Once you have established a good trace, turn scope OFF and re-insert IC201. Turn scope back ON and if trace does not re-appear, see "SERVICING HINTS" section that follows.

COMMON PROBLEMS	SERVICING HINTS
No Trace (IC201 out)	This condition could be caused by component failure in the CRT filament circuitry, the low and high voltage power supply circuitry or improper balancing of the output transistors in the horizontal or vertical amplifier sections.
No Trace (IC201 in)	This can be caused by a defective IC201 or trouble in the trigger amplifier sections, the trigger sweep circuitry, or the blanking circuitry. Many of these problems can be eliminated through recalibration. (See manuals 9560-3, Part 1 and Part 3)

COMMON PROBLEMS	SERVICING HINTS
Trace Disappears After Warm Up	This problem will usually result from improper trigger-blanking or high voltage power supply troubles. It could also be caused by defective components such as IC201 or Q202. Refer to the Trigger Sweep and Power Supply Sections.
Improper Focusing	This is commonly caused by low voltages on the CRT. Before troubleshooting the circuits, check for adequate high voltage (High Voltage Test) and reset the focus and astigmatism controls. Refer to the Power Supply and Appendix Sections for tests.
Cannot Adjust Intensity	Transition between beam "on" or "off" is normally slight. Check the intensity potentiometer, it should be marked 25K ohms. If it is not, contact the Instruction Department to order the proper control.
Vertical Positioning	Perform the Modified Vertical Calibration Procedure outlined in the Appendix. See the Vertical Section of this manual if difficulty is encountered.
Horizontal Positioning	Check the horizontal amplifier calibration. (See manual 9560-3, Part 1). Refer to the Horizontal Section if difficulty is encountered.
No Trace, R208 Overheats	This problem originates in the power supply high voltage section. Refer to the Power Supply Section for test procedures.
Can't Vary TP-1 Voltage (Q301 Source Voltage)	Check for TP-1 short circuit to chassis.
Can't Adjust C412 for 2cm Display (Calibration)	This is usually caused by improper sweep calibration. Recalibrate Sweep Cal control as outlined in manual 9560-3, Part 3.
Abnormal Vertical Line or Enlarged Dot or Flare at Beginning of Trace	Trace is not blanked properly by IC201. Refer to Power Supply Test Section.

Trace Drifts Horizontally or Is Hard to Stabilize.	This action is caused by improper triggering or lack of trigger signal. Check Internal/External trigger switch and refer to Trigger Sweep Circuitry.
Compression on Right Side of Trace	A problem often caused by improper adjustment of Feedback Adjust or DC Balance. Check calibration (See manual 9560-3, part 1) and refer to Trigger Sweep Circuit Section if you encounter a problem.
Trace is Unstable at High Frequencies (Ex: 500KHz Calibration Adjustment)	This problem is caused by the slow response of IC201. Modify the circuit by placing a 1K ohm, 1/2 watt resistor between pins 1 and 2 of IC201.
Trace Appears to Shift Toward Right Side as uSEC/CM Switch is Rotated Through Ranges	This is caused by the Q203 blanking circuit response. Modify the circuit by adding a silicon diode from Q203 emitter to ground. The diode cathode is connected to ground. See Appendix for modification procedures.

ADDITIONAL SERVICING NOTES:

If you are still experiencing difficulty in locating the area of trouble, stop and analyze the trace for clues.

A trace showing vertical gain problems or clipping indicates problems with the Vertical Circuitry.

A trace showing horizontal width or compression problems indicates possible defects in Horizontal and Trigger Sweep Circuitry.

A frequency or timing problem would be related to the Trigger Sweep Circuitry.

Details of operation of all circuitry are in Section II.

Enclosed in Section II is the Block Diagram of the Solid State Oscilloscope. If you are not experiencing problems similar to those listed above, read the "CIRCUIT DESCRIPTION AND TROUBLESHOOTING" Section in order to isolate the problem. Do not rush through the explanations or skip any parts unless you are sure you know the exact area of trouble.

SECTION II

CIRCUIT DESCRIPTION AND TROUBLESHOOTING

IMPORTANCE OF UNDERSTANDING CIRCUIT OPERATION

The most important step in effective troubleshooting is to determine how the stage or circuit should operate under normal conditions. Without this knowledge, much of your time will be wasted by stumbling blindly through a circuit while hoping for an obvious answer. Stop and review circuit operation to improve your chances of finding the problem.

After reviewing circuit operation, proceed by checking the following:

(1) Determine the symptom(s) -- Observe the operation or lack of operation of the oscilloscope.

(2) Make initial checks -- Follow the test procedures at the end of each section.

(3) Locate the faulty stage -- When the stage is isolated, make specific voltage and resistance measurements. In some cases you may have obtained this information from your initial checks. Often a part is replaced after much expense and work, only to burn up immediately after power is applied; to prevent this, ask yourself the following questions:

> What is the function of this part? Were all associated components checked? How does the circuit work in which the part is located? Were all voltage measurements in the circuit checked? Was the component drawing excessive current or none at all?

Now begin reading the Circuit Description of the Solid State Oscilloscope and the Troubleshooting Explanation. Refer to the Block Diagram, Figure 1, and the Schematic, Figure 6, as you read the theory.

BLOCK DIAGRAM

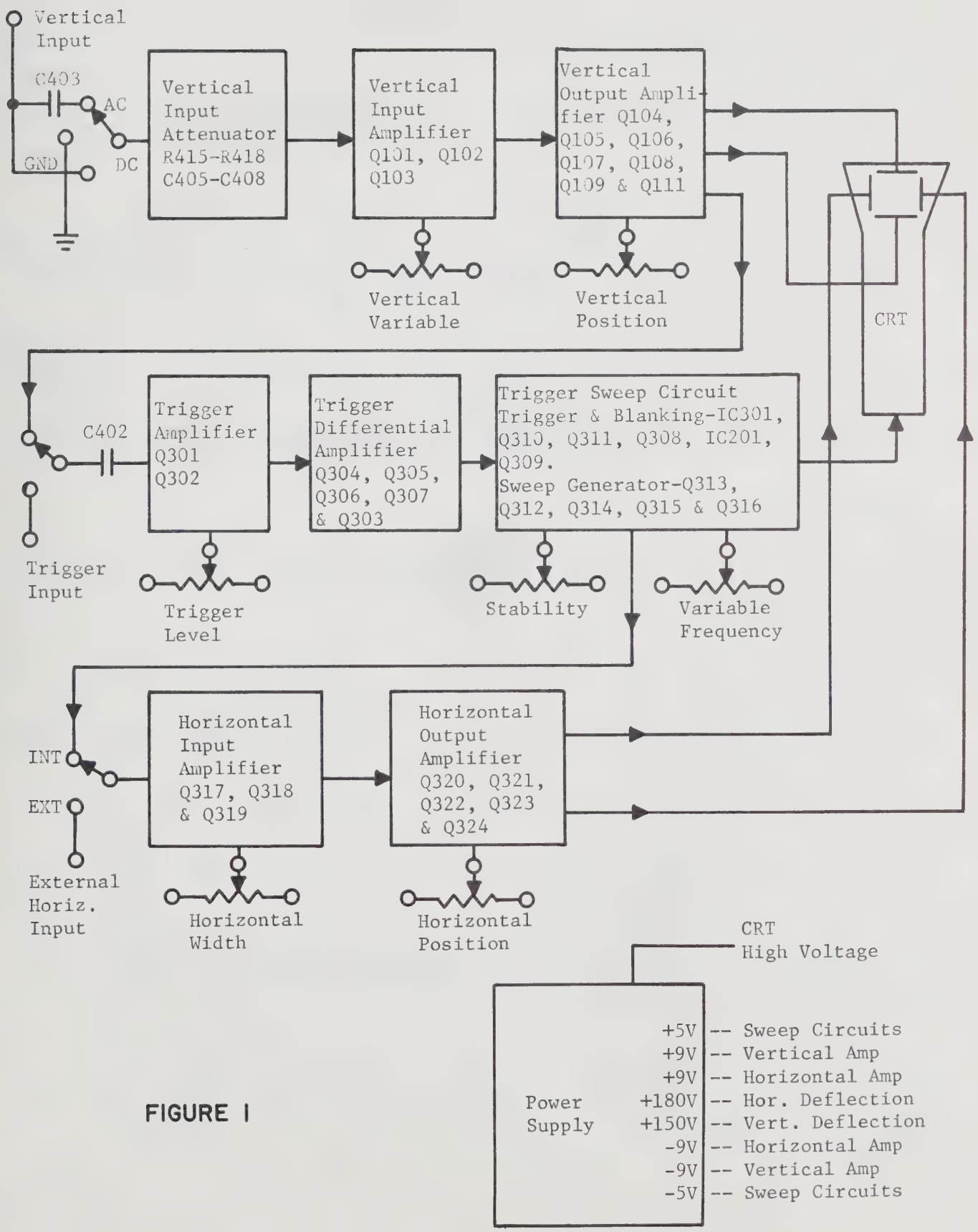


FIGURE 1

VERTICAL CIRCUITRY

VERTICAL INPUT ATTENUATOR

The purpose of the vertical input attenuator is to reduce the amount of input signal to the vertical amplifiers. A resistor voltage divider network, R415 through R418, is used to divide any input voltage down to a level that will not over drive the amplifiers.

To maintain a flat frequency response with a 5 megahertz bandwidth, the vertical input attenuator is frequency compensated. This is accomplished by capacitors C405 through C408. The MODE switch, in series with the input jack, converts the oscilloscope input coupling from DC to AC. AC coupling is achieved by placing a capacitor, C403, in series with the input to prevent any DC component from entering the vertical amplifiers.

Troubles commonly found in the Vertical Input Attenuator are loss of signal due to component failure in the voltage divider, excessive signal due to an open voltage divider component, or frequency response problems due to capacitor failure. If you have any of these problems, perform the Vertical Input Attenuator and Amplifier Tests at the end of this section.

VERTICAL INPUT AMPLIFIER

The purpose of this circuitry is to provide control of the input signal through calibration and variable controls, to provide high input impedance with low output impedance, and to provide high voltage input protection.

The basic circuit is made up of two source followers, Q101 and Q103, and a constant current source, Q102. A source follower is used because it has high input and low output impedances. The high input impedance of Q101 reduces the oscilloscope's loading effect on any circuit being tested. The low output impedance of Q103 is used to drive the differential amplifier stage to keep losses at a minimum. Q102 is a constant current source that regulates the source voltage of Q101 at zero volts. The source voltage of Q101 must be at zero to keep the vertical trace from moving up or down as you adjust the Vertical Variable Control. Q102 also acts as a linear source resistance; this produces an amplifier gain more linear than a resistor could achieve. The DC Balance control adjusts the Q102 current to keep the Q101 source voltage at zero. Diodes D103 and D104 are voltage references for the constant current source. The vertical variable and calibration controls act as voltage dividers which enable you to adjust calibration and operational voltage levels. Diodes D101 and D102 are utilized as a protection device; they limit any signal to approximately ±9 volts at the gate of Q101 by acting as high impedance zener diodes.

Problems found in this section would relate to AC calibration and DC (Vertical) trace positioning. Calibration and signal level problems could be due to a defective amplifier section. If you encounter a problem, perform the Vertical Input Attenuator and Amplifier Tests at the end of this section.

A Common Calibration problem may occur when the Q101 source voltage is adjusted through zero volts. The adjustment will "jump" a small voltage range as you adjust the DC balance. This indicates nonlinearity in the conduction of Q101. The results of this problem could show up as a Vertical drifting trace. Most often this is caused by a defective FET, Q101. Replace Q101 and Q102 together for a positive cure. This type of transistor defect will not show up on the Transistor Test Circuit (See Appendix).

VERTICAL INPUT ATTENUATOR AND AMPLIFIER TEST

This test is to provide a method of signal testing the vertical input attenuator and the vertical input amplifiers utilizing the DMM (Digital Multimeter).

PART A -- This part examines AC voltage levels at certain points for comparison purposes. We will trace the calibration voltage (1 volt P-P) path through the vertical input attenuator up to the vertical differential amplifiers, (Q105 and Q106).

NOTE: Scope "ON" (controls not listed can be disregarded and the trace need not be visible), control settings as follows:

CONTROL	POSITION
VERTICAL VARIABLE	CW
INPUT SWITCH	Calibrate
VOLTS/CM	.03
MODE	AC
VERTICAL CAL	CW

Vertical Calibration, R103, is located on the vertical circuit board. All measurements are AC voltages, RMS. Connect black test lead to ground.

TEST POINT (RED TEST LEAD)	MEASUREMENT	TYPICAL VALUES
1VP-P Output Jack	_____	.39 VAC
"A" (Vertical Circuit Board)	_____	.39 VAC

Measure the Q101 DC source voltage for a zero reading. (Reverse the DMM leads to insure a negative voltage is not present.) If you do not read zero, repeat the vertical calibration procedures (9560-3, Part 1). If trouble persists, refer back to "VERTICAL INPUT AMPLIFIER description."

Q101 Gate	_____	.38 VAC
Q101 Source	_____	.38 VAC
Q103 Gate	_____	.37 VAC
Q103 Source	_____	.2 VAC

PART B -- Scope "OFF"

The position of the controls is the same as Part A. Remove the yellow wire from lug A of the vertical circuit board. Make the following resistance measurements from the yellow wire to chassis ground as the Volt/CM switch is turned:

VOLT/CM POSITION	RESISTANCE	TYPICAL VALUES
30 V/CM	_____	990 ohms
3 V/CM	_____	10.1K ohms
.3 V/CM	_____	100K ohms
.03 V/CM	_____	990K ohms
GROUND	_____	Zero Ohms

If you are still having Vertical problems, continue on with the Vertical Output Amplifier.

VERTICAL OUTPUT AMPLIFIER

The vertical output amplifier provides sufficient amplification of any input signal in order to drive the CRT deflection plates. This amplifier is composed of a differential amplifier stage which drives two pairs of direct coupled common emitter amplifiers. This combination creates a balanced two-sided amplifier. One side is Q105, Q107 and Q109 while the other side is Q106, Q108 and Q111. Since this is a very high gain DC coupled amplifier, both sides must be matched and regulated. Q104 acts as a constant current source that regulates the bias on the differential amplifier. Transistor Q104 is a current regulator, it sets the current available to the differential amplifier. The regulator reference voltage is supplied by diodes D103 and D104. The 100 volt adjust sets the forward bias on Q104 which establishes the current output level available to the differential amplifiers (Q105 and Q106). In normal operation (trace centered on CRT) the bias on Q105 will equal the bias on Q106. If we adjust the vertical position control to shift the base voltage on Q106 more positive, Q106 will conduct harder. (This action simulates a signal applied to the base of Q106.) The Q106 current will increase causing the collector voltage to decrease and the emitter voltage to increase. The increased Q106 emitter current will cause the emitter current of Q105 to decrease due to the fixed output current of Q104. The collector voltage of Q105 will increase due to a decreased emitter current. The collector voltage of Q106 will decrease due to its increased emitter current. If the Vertical Position Control is turned the opposite direction, all voltages and currents reverse. Normally, the Vertical Position Control sets the Q105 base voltage equal to the Q106 base voltage. Any input signal applied to the base of Q105 has the same results as changing the position control. The output of Q105 is fed to the base of an upside down common emitter amplifier, Q107. The output from Q107 drives Q109 which in turn drives one vertical CRT deflection plate. The output from Q106 drives the other common emitter amplifier, Q108. Q108 then drives Q111 the other vertical deflection plate amplifier.

Most problems in this circuit are created by misadjustment of the 100 Volt Adjust and Vertical Position Controls. If the controls are not correctly set, the circuit might draw too much current causing the +9 volt DC supply to load down. Other misadjustments might result in vertical clipping.

If you encounter difficulty, try recalibration using the revised Vertical Calibration Procedure, (See Appendix). If trouble persists, refer to the Vertical Output Amplifier Test.

VERTICAL OUTPUT AMPLIFIER TEST

The purpose of this test is to provide a means of testing the linearity of the vertical output amplifier section. This can be done because the voltages on Q105 should match the voltages on Q106. Q107 should match Q108, and Q109 should match Q111.

1. Measure the voltages at points G and H, G should read between 8.5 and 9 volts, H should read between 100 and 250 volts. If these voltages are out of tolerance, recalibrate the stage using the Revised Vertical Calibration Procedure (See Appendix). If trouble persists, see the troubleshooting section on power supplies.

2. Measure the source voltage on Q101, it should be zero. (Reverse DMM leads to check for negative voltage.) If voltage is not zero, recheck calibration of DC balance control.

3. Measure the voltage on the base of Q105. It should be approximately 0.43 volts. If not, check the Q105 and Q103 circuitry. Set the voltage on the base of Q106 equal to the voltage on the base of Q105. If difficulty is encountered, your problem would be in the vertical position controls, R404, C102, or Q106.

4. Set the 100 Volt Adjust control to produce -0.5 volts on the collector of Q104. If you cannot adjust within 0.3 volt of this voltage, check Q104, Q105, Q106, D103 and D104.

   NOTE: The normal range for the Q104 collector voltage is between zero and -2 volts ±20%.

   Compare the following pairs of transistors. The voltages should match, although actual voltages are not important.

NORMAL TOLERANCE	COMPARE		
	Q105	to	Q106
Should be same	B		B
±.3V	E		E
± 1V	C		C
	Q107	to	Q108
± 1V	B		B
± 1V	E		E
± 1V	C		C
	Q109	to	Q111
± 3V	B		B
± 3V	E		E
±10V	C		C

If the balance is off between a transistor pair, remove them from the circuit and check them. Always take the pair of transistors with the greatest voltage deviations first. Use the Transistor Test Circuit in the Appendix to test the transistors if necessary.

TRIGGER SWEEP CIRCUITRY

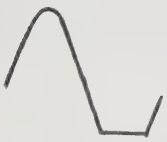
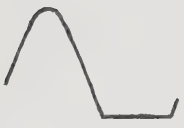
TRIGGER SIGNAL AMPLIFIER

The purpose of the trigger amplifier is to provide (1) amplification for the triggering signal, (2) a means for adjusting the trigger timing and (3) negative and positive slope selection.

Resistors R116 and R117 (vertical amplifier board) form a voltage divider used to feed a portion of the vertical output signal back to the trigger amplifier. This signal, a reproduction of the vertical input signal, or an External trigger signal, is coupled through Q301 to the differential amplifier, Q304 and Q305. Transistor Q301, a source follower, is biased by transistor Q302 (a current regulator or constant current source). Diodes D301 and D302 act as zener diodes limiting the input signal to ±9 volts to protect Q301. Transistor Q303 acts as a constant current source for the differential amplifier transistors. The output from the differential amplifier is amplified by a pair of emitter follower amplifiers, Q306 and Q307.

Q301 is used as a source follower because of it's high input and low output impedance. Q302 controls the bias on Q301; the Level Set Control is used to adjust the current through Q302 to produce zero volts on the source of Q301 while in the AUTO position. In the NORMAL position, the Level Control can be used to offset the zero voltage on Q301 source which will result in Q304 clipping the trigger signal. By varying the Level Control, you can change the amount of clipping (See Figure 2).

TEST POINTS

1 Q304 Emitter	2 Q306 Emitter	3 Q307 Emitter	Position of Level Control
A1	B1*	C1*	Maximum CCW
A2 	B2	C2	1/4 Turn CW
A3 	B3	C3	1/2 Turn CW
A4	B4	C4	3/4 Turn CW
A5	B5	C5	Maximum CW

These drawings show how the triggering signal changes as the Level control is adjusted.

*Wave forms are not illustrated due to distortion caused by circuit balancing error at this low level.

FIGURE 2

Waveforms A1 through A5 show the complete action of the Level Control; these waveforms should be present at the Q304 emitter. Waveforms B1 through B5, Q306 emitter, and waveforms C1 through C5, Q307 emitter, are triggering voltages for IC301 that are available by changing the slope switch. The triggering signal is taken off at the emitters of Q306 and Q307 because the output signals are 180 degrees out of phase, therefore, either emitter output can be switched to trigger IC301A. This results in negative and positive slope triggering.

The phase inversion of the waveform on the CRT screen is controlled by the trigger input to IC301A. The actual start of the CRT trace is controlled by the setting of the slope switch and Level Control adjustment which sets the amplitude and phase of the trigger input to IC301A. The trace on the CRT will start only when the trigger input is approximately -1 volt. IC301A must wait for the negative portion of the trigger waveform to start the trace, therefore, you can see that this results in trace inversion due to triggering on the opposite slope.

The adjustment of the Level Set control is critical. You must be able to set the Q301 source voltage at zero. (See Calibration Procedures 9560-3, Part 1.) If you cannot adjust for zero, the problem may be in the Q301, Q304 or Q302 circuitry. Check the transistors in the Transistor Test Circuit (See Appendix) and perform resistance tests on the bias circuitry. When adjusting for zero volts on the Q301 source, you will observe a swing from a negative to a positive voltage. (Remember to reverse the DMM test leads.) The voltage swing should be a linear change (no sudden jumps in voltage level) as the Level Control is slowly adjusted. An abrupt change would possibly indicate a defective Q301 or Q302. If either are defective, replace both.

If you have trouble with triggering, calibration of the Trigger Balance Control may be off. With the oscilloscope in the "Normal Position" and the Q301 source voltage at zero, the Level Control can be used to test the differential amplifier. Measure the voltage at the emitter of Q306 and vary the Level Control through its entire range. You should measure approximately the range of -1 to +3 volts. Measure the voltage on the emitter of Q307 and vary the Level Control again. The voltages should vary in the range from approximately -1 to +3 volts here also. You should be able to get at least a zero to +2.5 volts range at minimum. If you still have a problem, refer to the "Differential Amplifier Test."

TRIGGER DIFFERENTIAL AMPLIFIER TEST

This test provides a means of testing the Trigger Differential Amplifier linearity. Since the voltages on Q304 should match the voltages on Q305 and the voltages on Q306 should match the voltages on Q307, we can compare the transistor voltages for testing purposes.

1. Check the voltages on points HH and E of the Horizontal Amplifier Board. HH should read between 4.5 and 5 volts and E should read between -4.5 and -5 volts. If not, refer to the Power Supply Section for testing procedures.

2. Set the Sweep Trigger Switch to AUTO mode. Check the voltage on the source of Q301 (TP-1). The voltage should be zero; if not, check calibration of the Level Set control. If difficulties are encountered, check the Q301, Q304 and Q302 circuitry.

3. Set the Trigger Balance Control to produce a voltage drop between 1 to 2.5 volts across resistor R310. To do this, place the red test lead of the DMM at the collector of Q306 and place the black lead of the DMM at the collector of Q304. Adjust the Trigger Balance for a 1 volt reading. If you cannot measure this voltage, check transistors Q303, Q304 and Q305. Check the circuitry associated with these transistors for possible errors.

Compare the following transistor pairs. The voltages on the transistors should match within tolerance range.

NORMAL TOLERANCE	COMPARE		
	Q304	to	Q305
Same Voltage	B		B
±0.3V	E		E
± 1V	C		C
	Q306	to	Q307
± 1V	B		B
± 1V	E		E
± 1V	C		C

If the balance is out of tolerance between a pair of transistors, remove them from the circuit and check them in the Transistor Test Circuit. (See Appendix)

TRIGGER SWEEP CIRCUIT

The trigger sweep circuit can be divided into three sections. These are the triggering and blanking stages (IC201, IC301, Q203, Q308, Q309, Q310 and Q311), the sweep generating circuit (Q313, Q312 and a selection of sweep capacitors located on S402) and the stabilizing control circuit (Q314, Q315, Q316 and the Stability Control, R408).

Since the trigger sweep circuit operates in continuous cycles, (each cycle being triggered by voltage from the trigger amplifier), it is necessary to have some fixed reference point to start an explanation. It is important to understand how the individual stages operate, therefore, the three sections will be discussed individually and then explained as a unit.

The triggering and blanking circuit functions as follows: IC301A and IC301B are NAND gate Schmitt triggers having positive and negative thresholds with an approximate 0.8 volt difference

between thresholds. The positive-going threshold voltage is approximately 1.7 volts and the negative threshold voltage is 0.9 volts. Four inputs are available to each Schmitt trigger but only two are used in IC301A and only one is used in IC301B. Unused inputs are left unconnected and as such are "high" in potential. Keep in mind that all unused inputs must be high in order for the trigger to change states. To produce a "low" at the output, all inputs must be "high". To produce a "high" at the output only one input must be "low".

Certain control settings must be assumed in order to analyze the operation of this circuit. With the AUTO/NORM switch in the NORM position, the slope switch in the plus position, the Level Control fully counterclockwise, and the Stability Control fully counterclockwise, the following circuit action will take place. Note: Assume a positive input signal is applied to the vertical input amplifier.

With the Stability Control rotated counterclockwise, approximately +5 volts will be at the anode of D305. This +5 volts will be applied to the input of IC301B, placing this input well above the positive threshold level, resulting in a low at its output which biases both Q308 and Q311 off. With Q308 cut off, the high potential that appears at the collector serves two functions. One function is to allow the input circuit of IC301A (terminal No. 1) to accept an input signal by placing the input at pin 4 of IC301A in a "high" state. The other function is to turn on Q309 which turns ON the LED and optical transistor of IC201 which then biases off Q202 resulting in beam blanking. The increased collector voltage of Transistor Q311 biases on Q203 and Q312. The decreasing collector voltage of Q203 reduces the forward bias of the CRT blanking the trace. Transistor Q312 is saturated and provides a short circuit discharge path for the sweep capacitors.

To set up the scope in a state ready to produce a trace, the Stability Control is adjusted to a point where the input of IC301B is just above its negative threshold. With the trigger circuits in this condition, the following action will take place if a positive-going signal is fed into the vertical amplifier. The action of this circuit has been discussed, therefore, we will pick up the signal at the output from the Q307 emitter. The emitter of Q307 (going negative) will feed into terminal 1 of IC301A resulting in a "high" output (Lug 4 of IC301A was also at a "high" state). A "high" at the base of Q310 produces a negative pulse at the collector which is coupled through C304 to the input of IC301B. The negative going pulse (if the Stability Control is set properly) will drop the input of IC301B below its negative threshold and thus cause the output to go "high". A "high" at the output of IC301B turns on transistors Q311 and Q308. With Q308 conducting, its collector is low preventing further change of state in IC301A for the remaining portion of the sweep interval. The "low" at the collector of Q308 also turns off Q309 which turns off the LED and the photo transistor in IC201, and allows Q202 to conduct turning the CRT beam ON.

Returning to Q311, the collector goes "low" turning off Q312 permitting the sweep capacitor to charge. The collector of Q311 also biases off Q203 placing the collector at approximately 68 volts. Thus the sweep interval has been initiated. As the sweep capacitor charges, the positive voltage developed is applied to the input of the horizontal amplifier and the gate of

Q314. The beam is now sweeping across the screen from left to right while the positive going voltage is also applied to Q314 gate resulting in its source going proportionately positive. The increasing voltage at the base of Q316 finally exceeds the positive voltage set at the emitter of Q316 by the Stability control. This voltage turns on Q316. As Q316 is driven towards saturation, the voltage at the emitter continues to rise until it exceeds the positive threshold at the input of IC301B. This causes the output to go low turning off Q311 and Q308. When Q311 turns off, the collector rises toward the supply voltage turning on Q203. The collector voltage of Q203 decreases causing capacitor C208 to discharge. The discharge path is from the top plate of C208 through resistor R412, developing a negative to positive polarity which is sufficient to bias the CRT beam off.

During the blanking interval, the collector of Q311 is "high" and turns on Q312 which discharges the sweep capacitor. Simultaneously, the collector of transistor Q308 is "high" (Q308 has been turned off by the "low" at the output of IC301B) turning on Q309 and IC201, turning off Q202 which (in addition to the blanking pulse) turns off the beam. The "high" at the collector of Q308 allows the input circuit of IC301A to accept an input trigger signal which will start a new sweep cycle. Keep in mind that when the sweep capacitor was discharged by Q312, the voltage, monitored by Q314 and applied to the input of IC301B through Q316, is now below the voltage level set by the Stability Control.

When the trigger AUTO/NORM switch, S405 and S406, is placed in the AUTO position, a different triggering circuit arrangement exists. While it functions basically the same, two major circuit changes occur when the switch is in the AUTO position. First of all, the base of Q302 is now set at a predetermined DC level by resistors R419 and R421. Also note that the input at pin 1 of IC301 is now AC coupled back to the trigger amplifier through C401 as well as DC coupled to the output of IC301A by way of a voltage divider made up of R318 and R319. The circuit now becomes self-resetting. The feedback voltage recycles IC301A at the end of each sweep cycle once the input of pin 4 of IC301A is enabled (high).

Let us briefly review the AUTO triggering sequence. Let us assume that the circuit is ready to receive triggering signals. A positive-going voltage, amplified by the vertical amplifier and the trigger amplifier, will appear as a negative-going signal coupled through C401 to input number 1 of IC301A. When the signal amplitude is adequate to trigger IC301A, the output of IC301A goes "high" resulting in a negative-going pulse being applied to the input of IC301B; the entire sequence follows the previously described sequence of events. The only difference is that the circuit is self-biased by virtue of amplifier design and becomes synchronous with the input signal.

Transistor Q313 is a constant current generator which charges the selected sweep capacitor on SW402. The DC voltage on the sweep capacitor is coupled to the horizontal amplifier to develop the horizontal sweep. The SWEEP CAL control adjusts the current in Q313. Width of the sweep, generated by the DC charging voltage across the sweep capacitor, is limited by the positive threshold at the input of IC301B. Thus, when the voltage rises above the positive threshold, the blanking interval begins and the sweep capacitor is discharged by Q312.

SWEEP TRIGGER CIRCUIT TEST

If you are having trouble with frequency calibrations, check the capacitors on SW402 and repeat frequency calibration procedures (9560-3, Part 3 Manual).

Problems in the sweep triggering area should be checked by performing the following "Sweep Trigger Circuitry Tests".

The purpose of this test is to provide a means of testing the complete blanking and trigger sweep circuitry.

All controls not listed can be neglected.

CONTROL	SETTING
VOLTS/CM	GND
INPUT	Operate
uSEC/CM	1mS
STABILITY	CCW
SWEEP TRIGGER	Normal and External
SLOPE	Positive

NOTE: All voltages for this test will be positive DC voltages and a trace need not be present.

1. Check the voltage at the emitter of Q307 with the Level control set at maximum clockwise (CW). It should be "zero". Measure the Q307 emitter voltage with the Level control maximum counterclockwise (CCW). It should be 3 volts ±20%. This voltage will be used to signal inject the trigger circuitry. If you cannot get these voltages, refer to the Trigger Amplifier Troubleshooting Section.

2. Fill out the first chart with the Level control "CW" then the second chart with Level control "CCW".

TEST POINT	LEVEL CONTROL SETTINGS	
	CW Measured Typical Value	CCW Measured Typical Value
IC301 pin 1	_____ (2.8)	_____ (0)
IC301 pin 6	_____ (.07)	_____ (2.6)
Q310 base	_____ (.03)	_____ (0.6)
Q310 collector	_____ (4.4)	_____ (.05)

This procedure tests the triggering section from IC301A to Q310. If you refer to the chart, you can see the change of state at each point as the level control is rotated.

The next part of this test will check the blanking and sweep triggering circuitry.

1. Set the Level control maximum CW.

2. Check the voltage at TP-2 with the Stability Control set "CCW", it should be +0.2 volts. If it is not, see calibration procedure in Manual 9560-3, Part 3.

3. Fill out the chart first with Stability Control "CW" then rotate it "CCW".

TEST POINT	LEVEL CONTROL SETTINGS	
	CW Measured Typical Value	CCW Measured Typical Value
IC301 pin 13	_____ (1.1)	_____ (3.6)
IC301 pin 8	_____ (1.9)	_____ (.07)
Q311 base	_____ (.7)	_____ (.07)
Q311 collector	_____ (.09)	_____ (1.7)
Q312 base	_____ (.08)	_____ (.6)
Q312 collector	_____ (1.5)	_____ (.06)
Q308 base	_____ (.7)	_____ (.05)
Q308 collector	_____ (.09)	_____ (4.4)
Q309 base	_____ (.09)	_____ (4.4)
Q309 emitter	_____ (.08)	_____ (3.7)
Q203 base	_____ (.08)	_____ (.7-2.0)
Q203 collector	_____ (70v*)	_____ (.09-2.0)
IC201 pin 1	_____ (.09)	_____ (1)

*Values may vary 5 volts or more.

The chart here also shows changes of state in transistor operation. If a particular transistor does not change state, it could be defective. Remember to check any external circuits for faults.

HORIZONTAL CIRCUITRY

This section contains the circuit theory and tests necessary to troubleshoot the horizontal amplifier circuitry. Refer to the block diagram (Figure 1) and the schematic contained in the Appendix.

HORIZONTAL INPUT AMPLIFIER

This circuitry provides control of the horizontal width of the input signal, prevents overloading through impedance matching and provides high voltage input protection.

The basic circuit is made up of two source followers, Q317 and Q319 and a constant current source, Q318. A source follower is used because it has a very high input and a low output impedance. The high input impedance of Q317 prevents overloading of the sweep input signal. The low output impedance of Q319 is used to drive the differential amplifier stage to keep losses at minimum. Q318 is a constant current source that regulates the source voltage of Q317 at zero volts. Q318 also acts as a linear source resistance which results in a more linear gain. The DC Balance Control adjusts Q318 current to keep Q317 source voltage at zero. Diodes D308 and D309 are a voltage reference. The Horizontal Width control acts as a voltage divider to control amplifier output. Diodes D306 and D307 are utilized as protective devices. They limit any input signal to approximately ±9 volts. These diodes act as high impedance zener diodes.

Troubles common to this section would be problems relating to sweep calibration and DC positioning. Calibration and signal amplitude problems could be due to a defective amplifier section. In this case, perform the Horizontal Input Amplifier Test. This test will localize the problem by signal tracing.

If you have any problem setting the Q317 source voltage at zero, you could have a problem with Q317, Q318, D308 or D309. This problem could show up as nonlinearity in the Q317 source voltage as you adjust the DC Balance. The voltages might jump as you adjust the control. The result can show up as a horizontal drift. Most often this is caused by a bad FET, Q317. Replace Q317 and Q318 together for a positive cure.

HORIZONTAL OUTPUT AMPLIFIER

The purpose of the horizontal output amplifier is to provide sufficient amplification of the horizontal sweep or any input signal in order to drive the CRT deflection plates. This amplifier is made up of a differential stage that is used to drive a pair of common emitter amplifiers.

This creates a balanced two sided amplifier. One side is Q321 and Q323 and the other side is Q322 and Q324. Since this is a very high gain DC coupled amplifier, both sides must be matched and regulated. Q320 acts as a constant current source that regulates the bias on the differential amplifier which in turn controls both sides of the amplifier. The reference voltage source for Q320 is diodes D308 and D309. The 100 Volt Adjust sets the forward bias on Q320 which establishes the operating bias for the differential amplifier.

The bias current output from the constant current source (Q320) divides between Q321 and Q322 (the differential amplifier). If Q321 and Q322 are balanced, the current will divide equally. Adjustment of the Horizontal Position Control shifts the bias voltage on Q322 simulating a signal. When Q322 conducts more current, the collector voltage decreases and the emitter voltage increases causing the emitter voltage of Q321 to increase. Since the base voltage of Q321 is set by the source current of Q319, the base of Q321 is held constant. Now, since the Q321 emitter voltage increased, the Q321 forward bias decreases. The collector voltage on Q321 now increases. If the Horizontal Position Control is turned the opposite direction, all changes of voltages and currents reverse. Any input signal applied to the base of Q321 has the similar biasing effects as changing the Horizontal Position Control in the base circuit of Q322. The output from Q321 drives Q323, which in turn drives one CRT deflection plate. The output from Q322 drives Q324, the other deflection plate amplifier.

The most common problems in this type of stage are created by misadjustment of the 100V Adjust. If the 100V Adjust is not correctly set, the stage might draw too much current causing clipping of the sweep signal. If the stage does not draw enough current, the transistors might cut off and also result in signal clipping. If this is the case, repeat horizontal voltage calibration. (See Manual 9560-3, Part 1.)

The Horizontal Position Control can be used to test the differential amplifier by varying the bias on Q322. The collector voltage swing on Q322 should approximately match the collector voltage swing on Q321 as the control is adjusted. This is also true for the other pair of transistors. Refer to the Horizontal Differential Amplifier Test.

HORIZONTAL INPUT AMPLIFIER TEST

The purpose of this test is to provide a method of signal testing the horizontal input amplifiers with the DMM. This is done by examining AC voltage levels at certain points for comparison purposes. The 1V P-P calibration voltage will be used as our test signal. This is equivalent to approximately .39V RMS.

Note: Scope is "ON" and controls not listed can be disregarded. A trace need not be present.

CONTROL	SETTING
uSEC/CM	EXT
WIDTH	Max CW

Check the voltage on the source of Q317. If it is not zero, recheck horizontal calibration (See manual 9560-3, Part 1) and review Horizontal Circuit theory.

In the next test, place a jumper wire between the 1V P-P jack and the Horizontal input jack. Then make the following measurements.

TEST POINT	AC VOLTAGE MEASUREMENTS	±10% NORMAL
R	_____ (±10%)	.39V AC
Q317 Gate	_____ (±10%)	.36V AC
Q317 Source	_____ (±10%)	.36V AC
Q319 Gate	_____ (±10%)	.36V AC
Q319 Source	_____ (±10%)	.34V AC

If any of your values are way out of tolerance, review circuit theory of Horizontal Input Amplifiers.

HORIZONTAL DIFFERENTIAL AMPLIFIER TEST

The purpose of this test is to provide a means of testing the horizontal differential amplifier section by checking the linearity of the stages. This can be done because the voltages on Q321 should match the voltages on Q322 and the voltages on Q323 should match Q324 when they are equally biased.

1. Check the voltages on points Q, P, and Y of the horizontal sweep circuit board. Q should read between 8.5 and 9 volts, P should read between -8.5 and -9 volts, and Y should read between 100 and 250 volts. If these voltages are out of tolerance, recalibrate the horizontal stage (See manual 9560-3, part 1). If voltage discrepancies exist, refer to Power Supply Section.

2. Check the source voltage on Q317, it should be zero. If reading is not zero, recheck calibration of DC Balance Control (See manual 9560-3 part 1).

3. Measure the voltage on the base of Q321, it should be approximately +0.3 to 0.5 volts. (If not, check the Q319 and Q321 circuitry.) Set the voltage on the base of Q322 equal to the voltage on the base of Q321 by adjusting the Horizontal Position control. If difficulty is encountered, your problem would be in the Horizontal Position Control, C306 or Q322.

4. Set the 100 Volts Adjust control to produce -1 volt (±0.5 volt) on the collector of Q320. If you cannot obtain this voltage, check Q320, Q321, Q322, D308 and D309.

   Compare the following pairs of transistors. The voltages should match within tolerance.

NORMAL TOLERANCE	COMPARE		
	Q321	to	Q322
Same Voltage	B____		B____
±.3V	E____		E____
±.5V	C____		C____
	Q323	to	Q324
±.5V	B____		B____
±.8V	E____		E____
±10V	C____		C____

If the balance is way off between a pair of transistors, remove from the circuit and check them. See Transistor Test Circuit in Appendix. Always check the pair of transistors with greatest voltage difference.

POWER SUPPLY CIRCUITRY

The purpose of the power supply board is to supply high and low voltages as well as provide trace blanking for operating the oscilloscope. The circuit board is divided into three main sections: (1) Low voltage regulated supply, (2) High voltage supply and (3) Blanking circuits.

LOW VOLTAGE SUPPLY

The theory of operation will be discussed and it is suggested that you follow the explanation while referring to the scope schematic. (See Appendix)

The low voltage supply is equipped with positive and negative regulated outputs. Transistor Q201 is a series regulator and provides four levels of output voltage.

The secondary of transformer T401 (Lugs T and U) provides DC operating voltages for Q201 by using a bridge rectifier composed of diodes D203 through D206. Should the output voltage decrease (due to increased current demand), the resistance of Q201 will decrease resulting in less voltage drop across the transistor thus maintaining the output at a constant level. The opposite condition (increased resistance of Q201) will occur if load current decreases.

SOLID STATE OSCILLOSCOPE
CRT BIAS CIRCUITS

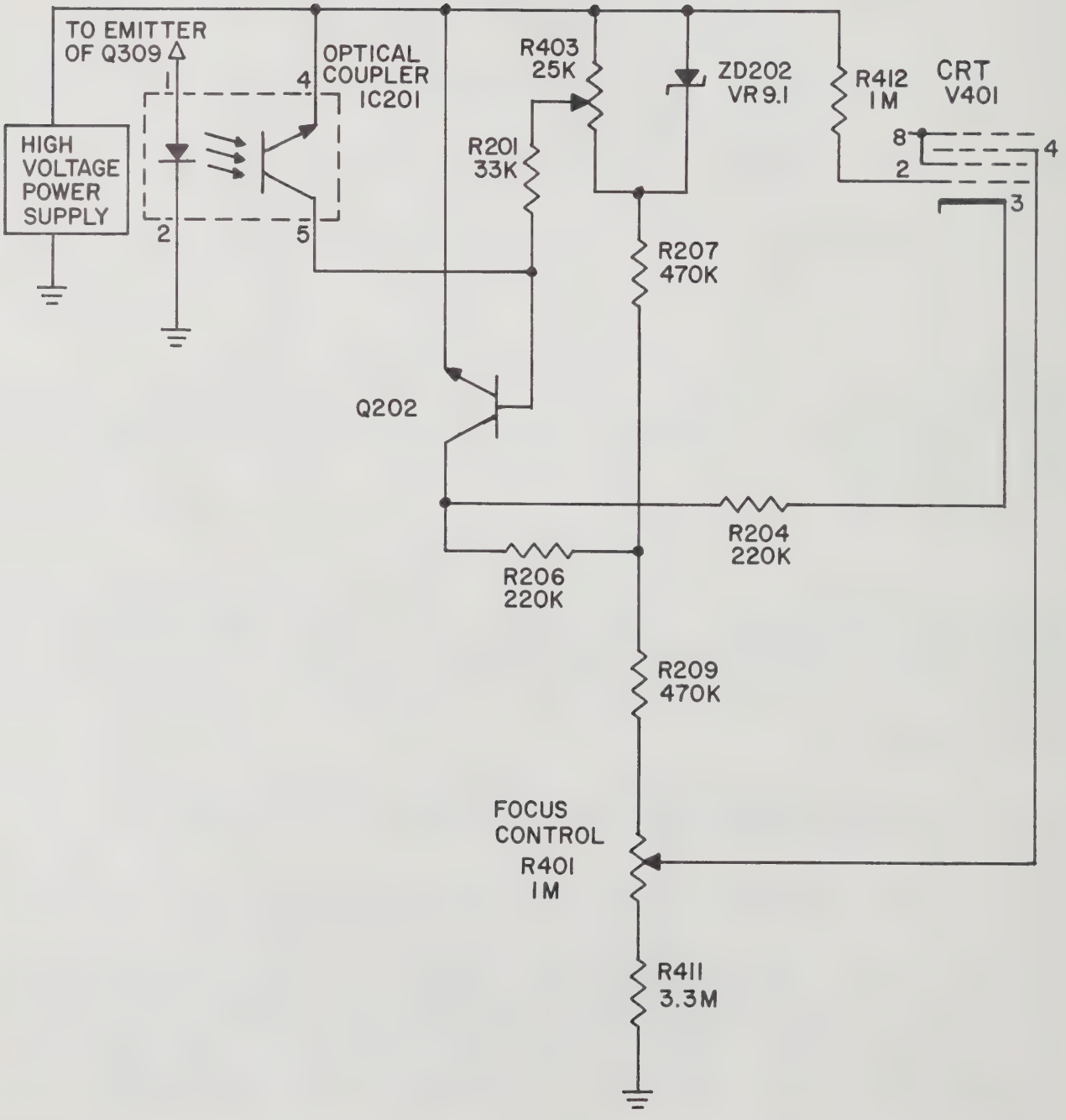


FIGURE 3

Resistor R218 provides a ground connection to the bridge rectifier. Current will divide at the junction of ZD201 and resistor R218 developing a voltage drop that will be negative with respect to the chassis ground. This negative supply voltage is fed through isolation resistors to lugs S, R, P on the circuit board.

Diodes D207 through D211 form another bridge rectifier. The 150 and 180 volt outputs from this circuit are filtered by C206. The 150 volt source supplies the vertical amplifier circuit board. The 180 volt source supplies the horizontal amplifier circuit board and blanking transistor Q203.

HIGH VOLTAGE SUPPLY

The high voltage supply is connected across the 800 VAC secondary of the power transformer, T401. A voltage doubler (diodes D201, D202, capacitors C203 and C204) is connected to capacitor C202 and resistor R208 which filters the DC output. ZD202 limits the voltage drop across the intensity pot, R403. This voltage drop is used to control the forward bias of Q202. The conduction of Q202 controls CRT bias and thus the brightness of the trace. It is important to mention that although only 9 volts is held constant across ZD202, a very high voltage potential exists on either side of this device with respect to chassis ground. MEASUREMENTS IN THE HIGH VOLTAGE SECTION SHOULD NOT BE MADE WITHOUT A HIGH VOLTAGE PROBE. (Refer to the Appendix for the High Voltage Test).

Figure 3 is a simplified drawing of the CRT Bias Circuits. Here are some important facts: The High Voltage Supply is drawn in block form and connects to IC201, R403, ZD202 and R412. When power is applied, current flows from the negative voltage source to the positive potential (ground). We will isolate one branch for the moment and explain the circuit action. R403, R207, R209, R401 and R411 form a series circuit, the sum of the voltage drops across them will equal the supply voltage. The Intensity control (R403), is in parallel with ZD202 and therefore, 9 volts is maintained across the control. By varying the Intensity control, the change of bias on Transistor Q202 changes the brightness of the trace on the CRT.

Q202 is a DC blanking amplifier that is controlled by the optical coupler, IC201. IC201 is an optical coupler which uses light for switching instead of an electrical connection. This circuit provides isolation between the low and high voltage sections of the oscilloscope. Inside the IC, there is an LED (light emitting diode) and a phototransistor. When the LED is turned on, light strikes the base region of the phototransistor, resulting in excitement of electrons in the base region thus turning on the phototransistor. IC201 receives signals from the sweep circuit to properly bias the CRT to turn the electron beam on and off. With transistor Q202 cut off, the CRT is biased off. When Q202 is conducting, its resistance is reduced biasing on the CRT. By varying the Intensity control, R403, the conduction of Q202 changes, thereby changing the brightness on the CRT.

It is important that you understand the main purpose of Q202 and Q203. Transistor Q202 in conjunction with IC201 provides DC blanking that keeps the beam off when a triggering signal is not present. The purpose of Q203 is to provide AC blanking of the trace between display

intervals. The voltage at the Q203 collector is coupled to the grid of V401 through capacitor C208. The range of voltage appearing at the collector of Q203 will vary between zero (when Q203 is on) and approximately 68 volts (clamped by zener diode ZD203). When a positive signal is applied to the base of Q203, it is biased on resulting in decreased collector voltage. The decreasing (negative going) voltage at the collector is coupled through C208 to the grid of the CRT resulting in trace blanking.

TROUBLESHOOTING THE POWER SUPPLY CIRCUIT BOARD

DO NOT MEASURE ANY VOLTAGE IN THE HIGH VOLTAGE SECTION WITHOUT A HIGH VOLTAGE PROBE.

The most common troubles experienced in the Power Supply Circuit board are breakdowns of components IC201, Q202, Q203, ZD202, D201, D202 and R208. The best way to check these semiconductors is through a front to back ratio test on the diode junctions. Note: Diodes D101 and D102 possibly may measure infinity both ways when testing for a front to back ratio. These measurements are normal because of the high voltage ratings of the diodes.

RESISTANCE TESTS:

IC201 RESISTANCE TEST CHART

DMM LEAD		TYPICAL MEASUREMENT	
Red	Black	Ohms	
Pin 1	2	_____	(123)
Pin 2	1	_____	(1M)
Pin 5	4	_____	(INF)
Pin 4	5	_____	(INF)
Pin 4	6	_____	(INF)
Pin 6	4	_____	(84)
Pin 6	5	_____	(80)
Pin 5	6	_____	(INF)

Q202 (Typical Values)

E -- B Junction	80 Ohms Forward	840K Reverse
E -- C Junction	INF Forward	INF Reverse
B -- C Junction	80 Ohms Forward	INF Reverse

Q201 (Typical Values)

E -- B Junction	65 Ohms Forward	840K Reverse
E -- C Junction	900K Ohms Forward	INF Reverse
B -- C Junction	65 Ohms Forward	INF Reverse

Power Transformer, T401, Typical resistances:

A-B = 1.5K ohms

T-U = 5 ohms

Z-Y = 80 ohms

L-M = Zero

APPENDIX A

REVISED VERTICAL AMPLIFIER BALANCE PROCEDURE
(Replaces Procedure on Page 3-45 of Manual 9560-3, Part 1)

Some difficulty may be encountered in achieving correct vertical amplifier adjustment using the vertical amplifier alignment procedure provided in Manual 9560-3, Part 1. Misadjustment appears on the CRT screen as limited vertical movement of the "spot" in an up and down direction. To check circuit operation and determine whether it is an adjustment problem, make the following checks.

1. Measure voltage at + end of C105. Reading should be approximately 8.6 volts. A low reading of about 4 to 6 volts indicates possible control misadjustment.

2. Check position of rotation of the "COARSE" vertical adjustment control. Almost full clockwise rotation will coincide with low voltage on C105.

3. Finally, check position of rotation of the "100 VOLT ADJUST" control. Almost full clockwise rotation of this control will confirm that an adjustment error has been made although possible circuit wiring or assembly errors must not be disregarded.

The following procedure is recommended for adjustment of vertical amplifier circuit.

1. Set vertical input selector to "GND" position and rotate vertical "VARIABLE" control counterclockwise.

2. Set Vertical "COURSE" and "FINE" controls and "100 VOLT ADJUST" to midrotation.

3. Measure voltage on + end of C105. It should now be approximately 8.6 volts (measured with Digital Multimeter). A continued low voltage reading will require further adjustment of vertical "COURSE" and "100 VOLT ADJUST" controls or a circuit check to locate an assembly error or a component failure.

4. Measure and record voltage at BASE of Q105. It should read approximately 0.43 volts.

5. Measure voltage at BASE of Q106 and adjust vertical "COURSE" control until base voltage of Q106 equals base voltage of Q105.

6. Adjust vertical "FINE" control and "100 VOLT ADJUST" control until both collectors of Q109 and Q111 are equally balanced at 100 volts. (NOTE: Do not use "COURSE" adjust control to make this 100 volt adjustment.)

7. Finally, set vertical "FINE" control to center position and touch up vertical "COURSE" control until voltage on base of Q106 again equals voltage on base of Q105.

8. "Spot" should now be centered on CRT screen and when vertical "FINE" position control is rotated, spot should move off screen, both top and bottom.

Complete remaining calibration procedures as outlined in the experiment manuals.

APPENDIX B

TRANSISTOR TEST CIRCUIT

The purpose of this circuit (See Figure 4) is to provide a general means of testing a transistor's DC characteristics out of circuit. It will work for NPN, PNP and FET transistors in this oscilloscope. This circuit runs each test transistor from cut-off to near saturation, by varying a bias control. Conduction of the transistor is measured by monitoring the voltage across a load resistor. At cut-off, the voltage across the resistor should be zero indicating no current flow. If a current exists, the transistor is shorted. As you adjust the bias control, the voltage on the meter should swing through a range from zero to a higher voltage as indicated in the chart.

Make sure you are using the correct basing diagram for the transistor. If in doubt, refer to the Construction Manual. Set the output of the Design Console at 25 volts.

NOTE: Points D, E and F in Figure 4 are the same for any type of transistor.

D -- Collector or Drain
E -- Base or Gate
F -- Emitter or Source

To test an NPN or FET transistor, make the following connections:

Point A to +DC
Point B to -DC
Point C to Red Lead of DMM
Point D to Black Lead of DMM

NPN And FET TRANSISTORS	APPROXIMATE RANGE (VOLTS)
EL131 -- 417-241	_____ (0-12)
2N3393 -- 417-118	_____ (0-17)
L842 -- 417-83	_____ (0-12)
MPSU10 -- 417-834	_____ (0-13)
2N2369 -- 417-154	_____ (0-12)
2N5294 -- 417-175	_____ (0-13)

To test a PNP transistor, make the following connections:

Point A to -DC
Point B to +DC
Point C to Black Lead of DMM

PNP TRANSISTORS	APPROXIMATE RANGE (VOLTS)
2N404	_____ (0-17)
X29A829 -- 417-201	_____ (0-17)

TRANSISTOR TEST CIRCUIT LAYOUT

P1 -- 5K ohm potentiometer
R1 -- 10K ohm resistor
R2 -- 10K ohm resistor
R3 -- 100K ohm resistor
R4 -- 4.7K ohm resistor
R5 -- 6.8K ohm resistor
R6 -- 1K ohm resistor

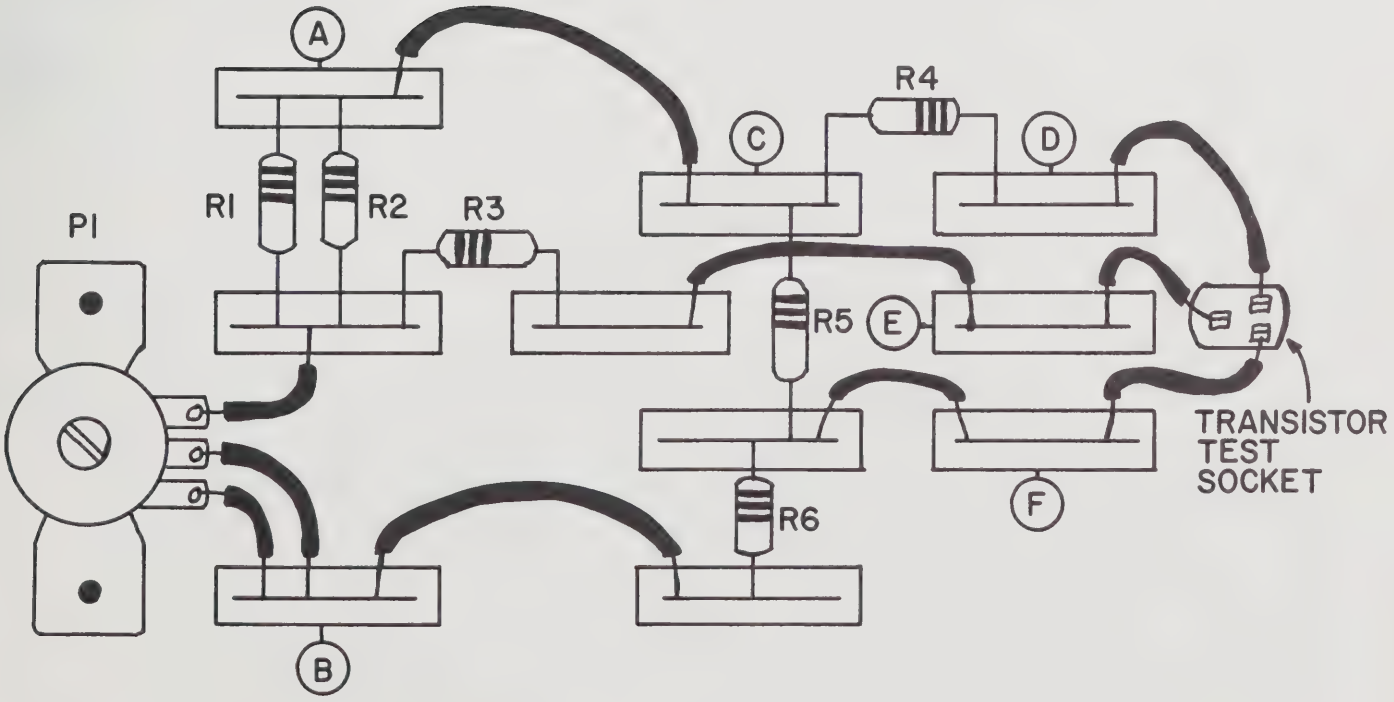


FIGURE 4

APPENDIX C

ZENER DIODE TEST CIRCUIT

The purpose of this test is to provide a means of testing zener diodes out of circuit. The best way to test a zener diode is to measure the voltage across the diode while under load. Set up the circuit, shown in Figure 5, on the design console with the component values from the chart for the particular diode you want to test. Measure the voltage across the diode, if it does not fall into the normal range, replace the diode.

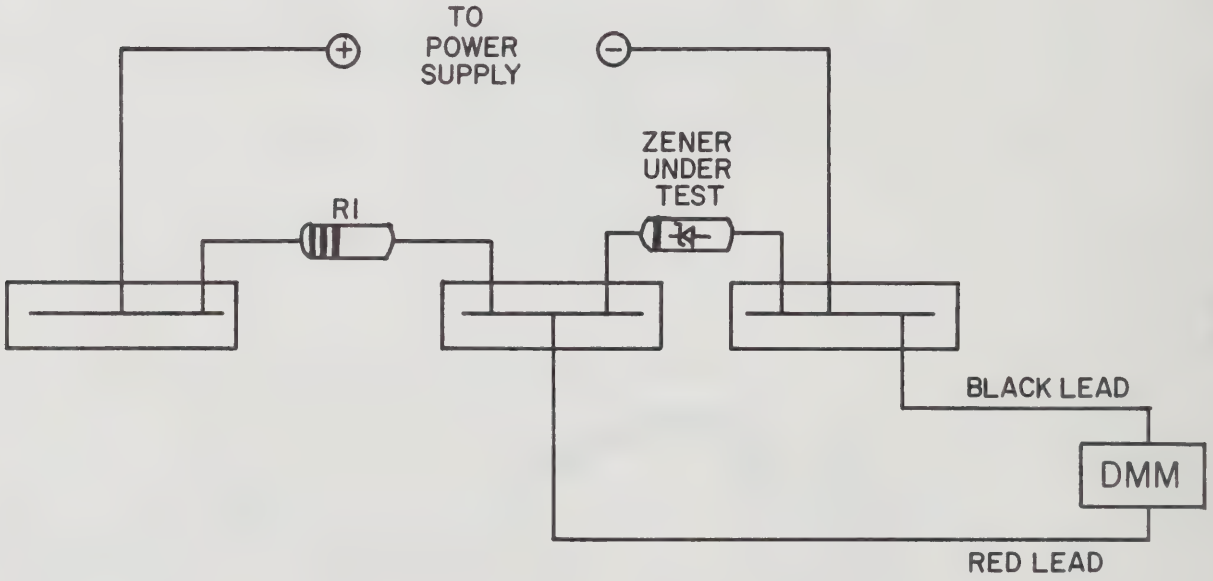


FIGURE 5

Diode	Zener Voltage	Power Supply	R1	Normal Tolerance Range
56-68	68V	180V	47K ohms	63V - 73V
56-55	36V	180V	100K ohms	32V - 40V
56-19	9.1V	30V	1K ohm	8 - 9.3V
56-44	4.6V	30V	1K ohm	4 - 5V

APPENDIX D

HIGH VOLTAGE TEST

The purpose of this test is to provide a method of checking for high voltage in the oscilloscope. This test is necessary because insufficient high voltage will prevent any visible presentation on the CRT screen. The results of this test will indicate if lack of trace is due to failure of the high voltage section of the Power Supply. This test should be made after completing the initial calibration procedures (9560-3, Part 1, page 3-45, step 8) when it is noted that a visible trace does not appear.

Repeat the control settings as listed under the Common Problems Section. Apply power; if a trace is present, the high voltage circuitry is okay. If a trace is not present, continue with the following test:

The DMM cannot be used for this test due to the high voltage transients that might be present. Use the small multimeter; set it to a 1000 VDC range. IMPORTANT: Plug red lead into 1000V jack if your meter has a 500 volt range combined with a 1000 volt range.

With the scope OFF, connect the black test lead to lug 3 and red test lead to lug 1 of R401, the Focus control. (See Manual 9560-3, Part1, page 3-20.) Turn the scope ON. If the high voltage section is okay, you will measure 300 volts or higher across the Focus control. If you obtain any measurement other than this, a problem may be indicated. Refer to the Power Supply Troubleshooting Section.

APPENDIX E

CIRCUIT MODIFICATIONS

The following modifications are intended to improve the general operation of the oscilloscope. They can be installed on all scopes including those not showing the apparent operational difficulty indicated for each modification. Improvement in operation may or may not be noticed unless your scope benefits from the modification.

LOW INTENSITY CAUSING SYNCHRONIZATION DIFFICULTY IN 1 uSEC/CM SWEEP RANGE

Connect a 1K ohm, 1/2 watt resistor, (Bell & Howell part number 24-41031), on the foil side of the power supply board from pin 1 of IC201 to ground. This places the resistor in parallel with the LED within the optical coupler (IC201) and results in a speed up of coupler switching at higher sweep speeds. The noticeable result will usually be a slight increase in intensity which allows correct adjustment of the STABILITY control for synchronizing higher frequencies.

CAUTION: Check to be sure lead wires of resistor do not short to other terminals on the power supply board.

LOSS OF A PORTION OF THE LEFT SIDE OF TRACE IN THE 1 uSEC/CM SWEEP RANGE

Insert a silicon diode (Bell & Howell part number 34-T159) into the emitter circuit of Q203. There are two types of power supply boards. If your board has a jumper wire connecting the emitter of Q203 to ground, simply remove the jumper wire and replace it with the diode. Be sure to connect the CATHODE end of the diode to ground.

If your power supply board has the emitter of Q203 connected to ground directly through the copper foil, you will have to make a cut through the foil to isolate the emitter from ground. Carefully scrape through the foil with a small knife. Then connect the diode across the separated foil sections so that the anode end is on the emitter terminal of Q203 and the cathode of the diode is on a ground connection.

The noticeable result of this modification will be an unblanking of the left end of the trace in the 1 uSEC/CM sweep range. The diode reverse biases Q203 slightly and reduces the width of the AC blanking pulse, allowing the lead end of the trace to be recovered (unblanked).

IMPROVING INTENSITY REGULATION AND HIGH VOLTAGE CIRCUIT RELIABILITY

Connect a 3.3M ohm, 2 watt resistor (Heath part number 1-38-2) from terminal number 1 of the INTENSITY control to the ground on the center of the front panel. If you already have a 3.3M ohm, 2 watt resistor connected from ground to lug number 3 of the INTENSITY control, move it to lug number 1. NOTE: If your scope has a 27K ohm resistor connected from lug number 1 to lug number 3 of the INTENSITY control, remove it as it will not be required.

APPENDIX F

Name _____ Student Number _____

Street Number _____

City _____ State Prov. _____ Zip Code _____

BELL & HOWELL SOLID STATE OSCILLOSCOPE OPERATIONAL REPORT

Is your Bell & Howell Solid State Oscilloscope working properly? Yes ____ No ____

(If yes answer, skip remaining questions and forward this sheet to the Instruction Department with explanation of trouble found.)

If your Oscilloscope is not working properly, can you control:

1. Vertical Beam Positioning	Yes ____	No ____
2. Horizontal Beam Positioning	Yes ____	No ____
3. Brightness of Trace	Yes ____	No ____
4. Focus	Yes ____	No ____
5. Vertical Gain	Yes ____	No ____
6. Horizontal Gain	Yes ____	No ____
7. Frequency of Trace	Yes ____	No ____
8. Trace Inversion (Use Slope Switch)	Yes ____	No ____
9. Stability of Trace	Yes ____	No ____

"No" answers must be explained in detail and submitted to the Instruction Department. Give a complete description of the problem and include all test results as obtained by following the procedures in this manual. (Use back side of this page if necessary.)

Explanation of Difficulty:

Cut on this line.

Explanation of Difficulty (Continued):

Cut on this line